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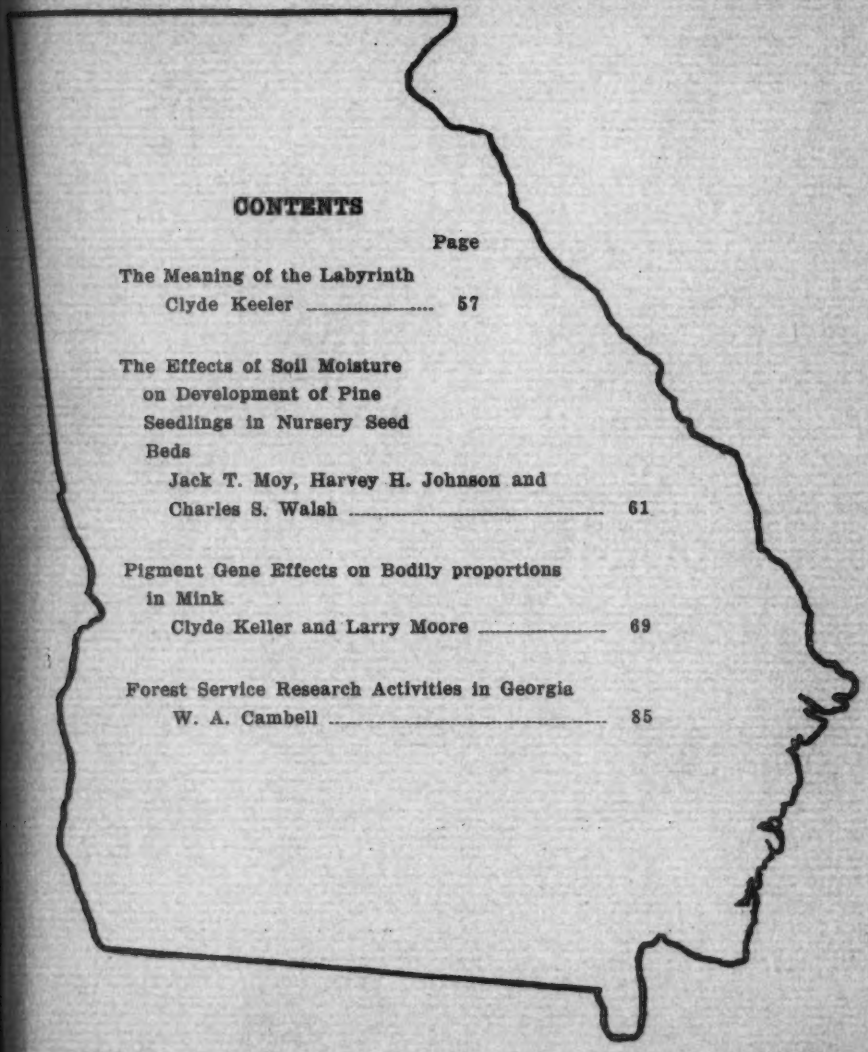

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THE MEANING OF THE LABYRINTH.

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In *The Outline of History* H. G. Wells writes "This peculiar development of the Neolithic culture which Elliot Smith called the heliolithic culture, included many or all of the following odd practices: (1) circumcision, (2) the very queer custom of sending the father to bed when a child is born, known as couvade, (3) the practice of massage, (4) the making of mummies, (5) megalithic monuments, (6) artificial deformation of heads of the young by bandages, (7) tattooing, (8) religious association of the sun and the serpent, and, (9) the use of the symbol known as the swastika for good luck." This heliolithic culture is said to have existed from 10,000 B.C. to 8,000 B.C.

The bronze age lasted from about 8,000 B.C. to 6,000 B.C. Baghouz and Samarra on the Euphrates, towns transitional between Neolithic and Bronze Ages, have yielded the first painted pottery known. Among this material are some votive bowls which demonstrate clearly that the swastika was then the Tree of Life turning in the Water of Life and giving rise to animals and fish, just as Chief Ikwaniktipippi tells me is the function of the Cuna Tree of Life today, often represented by American Indians as a swastika. In India the labyrinth is one of the sixty-five distinguishing marks on the feet of Buddha, and in the Afterlife it is under the Tree of Life in the midst of the labyrinth that the Hindu soul finally obtains rest. This Hindu Tree of Life is represented by a swastika.

Among the petroglyphs of the heliolithic age, carved on rocks all over the world, one finds swastikas with the arm tips coiled inwardly, and other designs that may represent primitive labyrinths. I have published[4] pictures of various swastikas having cubistically curved arm tips that make them into labyrinths, so there must be some ideological relationship between the swastika and the labyrinth.

The Coxons[2] have photographed labyrinth petroglyphs all over the world, and recently Bibby[1] has recorded their migration from Crete to Russia, Scandanavia, England and Ireland.

Now the most complicated form of this circummundane labyrinth was found on Cretan coins several thousand years B.C. It is so complicated that it could scarcely have been invented more than once, and in this complicated form it not only spread all over Europe as Bibby stated, but also found its way to India, to the Hopi Reservation in Arizona and to Mexico, as well as to many other places.

FIG. 1. *Spiral of eight turns upon which the labyrinth is constructed.* FIG. 2. *East (down) and west (up) branches of the Tree of Life showing the elaborate, meandering extension of their tips.* FIG. 3. *North (to right) and south (to left) branches of the Tree of Life showing elaborate, meandering extensions of their tips.* FIG. 4. *Lines of figures 2 and 3 produce the complete labyrinth.* FIG. 5. *Simple labyrinth produced by turning in the tips of the branches*

I have tried to analyze how the labyrinth was drawn. It is not based upon concentric circles as one might first suppose because one side of the entrance is farther from the center than is the other side of the entrance. Yet the distances between the concentric lines seem to be remarkably equal. These characteristics would result only if the labyrinth was based on a spiral or helix. See figure 1.

There are eight turns of the helix, and two meandering lines which cross each other at one place only. When the two meandering lines have been placed on the helix the labyrinth is complete. From the entrance one must pass through all the passageways in irregular order to reach the center. The sequence of passageways to be traversed we have numbered consecutively from one to eight. See figures 2, 3, and 4.

By studying simpler labyrinths one can gain an idea of how this labyrinth may have evolved. Chief Shup-She told me that when the Earthmother's children were removed from the Tree of Life (umbilical cord and foetal membranes) the branches curled under, and he pointed this out on Aztec representations of the Sacred Tree.

Curling the four arms of the cross (Tree of Life) in the same direction changes the cross into a turning swastika. However, if one coils them in opposite directions one can produce a primitive labyrinth. See figure 5. I have presented a full discussion of the labyrinth in a book[5] now in press to which the reader is referred.

The earliest swastika known comes from near Kiev, Russia, but the earliest labyrinth of the complicated form that we have been discussing hails from Crete. Some derive the word labyrinth from the word labrys, referring to the Sungod's double axe. Others say it could have the meaning of "tunnel", and I think this most probable because the Egyptian burial labyrinth visited by a Roman Historian consisted of confusing underground passageways. This apparently symbolized the area of the labyrinth in the Fields of Amenti through which the Egyptian soul must pass in the land of the Dead of the Egyptians in the Realm of Osiris.

Greek mythology has it that Pasiphaë, wife of King Minos, fell in love with a white, sacrificial bull and as a consequence gave birth to the Minotaur. Daedalus built the famous Cretan labyrinth of Egyptian design at Knossus to hide these three from the shame of that unnatural union. The Cretans denied this tale and Graves[3] thinks that the Minotaur story points to the ritual marriage under a sacred oak between the Knossian priestess, Pasiphaë, wearing cow's horns, and "King" Minos masked as a bull. It seems that in memory of this fertility ritual, dance floors were built all over Europe bearing the labyrinth design, to be used possibly in the erotic Easter Partridge Dance among others.

FIG. 1. *Spiral of eight turns upon which the labyrinth is constructed.* FIG. 2. *East (down) and west (up) branches of the Tree of Life showing the elaborate, meandering extension of their tips.* FIG. 3. *North (to right) and south (to left) branches of the Tree of Life showing elaborate, meandering extensions of their tips.* FIG. 4. *Lines of figures 2 and 3 superimposed to produce the complicated labyrinth.* FIG. 5. *Simple labyrinth produced by turning in the tips of the branches*

This labyrinth, as it appears on Cretan coins, is of the complicated form that we have described in detail above, based on eight concentric turns of a spiral, the paths so connected that the last one leads to a cross Tree of Life in the center of the maze. Each Moon-King (Minos) is thought to have reigned eight (a sacred number) years before being disposed of and replaced by a new "King". The Cuna priests before collecting the Apples of Immortality from the Tree of Life walk in a circle eight times about the Sacred Tree.

Chief Ikwaniktipippi identifies the Cretan labyrinth as a symbol, with the Tree of Life near its center, still drawn by Cuna medicine priests, in which to hide their patients from evil spirits. It is actually an x-ray-like picture of the Earth-mother's womb and entrails including her umbilical cord and foetal membranes (Tree of Life). It is a map of the maze of the Journey of the Afterlife of the Cunas when the soul returns for inspiration or for final death rest to the womb of the Great Earthmother.

Chief Shup-She tells me that the labyrinth symbol is found on rocks in many places in North America, seeming to indicate its very sacred nature in ancient ritual. In his opinion, the symbol of the coiled serpent, the twisted stem of the medicine pipe and the whirling logs of the Navajos "are all rooted in the labyrinth design." He knows it to be employed by the Chippewa, Hopi and Longhouse Iroquois, and thinks that it was used by the winter count of the Sioux.

Thus, in the labyrinth design we have a religious symbol that presumably originated some ten thousand years ago. It is based on the Tree of Life (cord and membranes) cross and to modern American Indians it represents the Earthmother's entrails. It is the Maze of the Afterlife through which the Cuna soul must travel, much as in the Hindu version, with many trials, choices and frustrations before it finally comes to rest at the Tree of Life in the Sacred Womb of the Great Earthmother.

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THE EFFECTS OF SOIL MOISTURE ON DEVELOPMENT OF PINE SEEDLINGS IN NURSERY SEEDBEDS.

JACK T. MAY[1], HARVEY H. JOHNSON[2], AND CHARLES S. WALSH[3]

During the past three decades, one of the major operations which has confronted nurserymen in southern pine nurseries has been the use of supplemental irrigation to make up for deficits in rainfall during the growing season. The big problem is, primarily, when and how often to irrigate. Fluctuations in rainfall during the growing season and variations in moisture holding capacity of different soils make it relatively difficult to develop a pattern of routine irrigations.

During the germination period (March 1 through May 15) and for about two months thereafter, irrigation is necessary for germination and establishment. Watering is much less important after the roots have reached a depth of four or five inches and enough primary needles have developed to shade the soil considerably.

It is commonly agreed that an internal water deficit in the plant resulting from drought reduces vegetative growth of most plants. There is still some disagreement concerning the extent to which soil moisture must be depleted before it hinders growth.

Two investigations of irrigation requirements are presented in this paper[7]. In 1953, an investigation was conducted on the effects of irrigation on loblolly pine (*Pinus taeda* L.) seedlings grown in the Auburn Nursery in Alabama. In 1959, a second study was conducted on slash pine (*Pinus elliotti* Englem.) grown in the Herty Nursery in Georgia.

PROCEDURE

The Auburn Nursery is located approximately seven miles east of Auburn in Lee County, Alabama. Approximately one acre of the nursery was set aside for the study. The soil was a Faceville sandy loam (Table 1).

Three irrigation treatments were established.

1. Irrigate when the height growth of the average seedling had apparently ceased due to lack of moisture.
2. Irrigate when the average height growth of seedlings decreased to one-half the maximum height growth made during a 24-hour period following the last rainfall or irrigation.
3. Irrigate according to standard nursery practice.

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Details of the experimental design, procedures, methods of measurements, and data collected are discussed by Walsh[6].

The Herty Nursery is located approximately two miles south of Albany in Dougherty County, Georgia. Approximately four acres of the nursery were selected for the experiment. The soil was a Eustis loamy sand (Table 1).

Three irrigation treatments were established.

1. Irrigate only when reasonably sure that plants are showing visible indications of wilting from lack of moisture and increasing moisture stress and in order to avoid loss of seedlings. Maintain soil moisture tension at, or above, three atmospheres.
2. Irrigate when soil moisture is reduced to 5.6 percent in the top six to eight inches or when a moisture tension of one atmosphere is reached. Try to maintain, if possible, a moisture tension of one atmosphere.
3. Irrigate when soil moisture falls below field capacity or a moisture content of 6.8 percent in the top six to eight inches. Try to maintain, if possible, a moisture tension of ⅓ atmosphere, which approximates field capacity.

Details of the study at the Herty Nursery are discussed by Johnson[2].

TABLE 1 — *Physical Characteristics of Faceville Sandy Loam and Eustis Loamy Sand Surface Soil.*

Soil Series	Particle Size Distribution			Average Field Capacity Moisture	Average Wilting Point Moisture	Bulk Density
	Sand	Silt	Clay			Grams
	percent			percent		percent
Faceville	75.0	17.3	7.3	9.7	3.8	1.60
Eustis	89.1	9.2	1.7	6.8	2.9	1.69

Soil moisture determinations were made daily in both studies, using gravimetric methods. Average weekly soil moisture content by specific weekly periods was determined.

Bouyoucos moisture blocks were used at the Auburn Nursery from July 23 through September 29. The meter readings were fairly consistent near actual field capacity, but fluctuated rather widely below field capacity.

Tensiometers and a neutron moisture probe were used at the Herty Nursery. Tensiometers were fairly accurate for measuring soil moisture at or near field capacity, but were useless when soil moisture tensions were above one atmosphere. Measurements obtained with the neutron probe were very close to those obtained by gravimetric methods, within all ranges of moisture tension.

RESULTS AND DISCUSSION

Investigations at two nurseries and during two different years reveal that brief droughts may not be too critical, and much of the supplemental irrigation during July through September could be omitted.

TABLE 2 — *Rainfall and Soil Moisture, Auburn Nursery, 1953.*

Period	Rainfall	Soil Moisture for Irrigation Treatment 1	2	3
	-inches-		percent	
7/1 - 7/7	.89	8.39	10.74	7.61
7/8 - 7/14	.46	8.64	10.54	9.02
7/15 - 7/21	5.04	10.47	11.74	10.71
7/22 - 7/28	.89	10.50	11.74	10.76
7/29 - 8/4	.01	6.99	8.09	8.67
8/5 - 8/11	.84	6.37	8.71	9.06
8/12 - 8/18	3.18	8.53	10.31	10.05
8/19 - 8/25	.31	9.58	10.36	9.69
8/26 - 9/1	.41	7.06	7.42	9.42
9/2 - 9/8	.04	5.65	7.59	10.02
9/9 - 9/15	.00	4.61	8.38	7.96
9/16 - 9/22	2.99	7.19	8.71	9.12
9/22 - 9/29	5.92	10.83	11.69	11.39
Number of Irrigations		0	4	9
Quantity of Water applied — inches		0	1.99	3.47
Average Amount applied per Irrigation inches		0	.50	.38
Field Capacity for Treatment Areas		8.6	10.6	10.0
Wilting Point for Treatment Areas		3.1	4.2	4.0

Rainfall at Auburn, Alabama, during 1953 was 76.35 inches, or 23.53 inches above normal. Rainfall totaling 20.98 inches was recorded during July, August, and September. This was 7.71 inches above normal for the period. The longest period without effective rainfall (over .2 inches) was 21 days from August 29 to September 19. The next longest drought period lasted 11 days, from July 28 to August 7. Except for these two periods, some effective rainfall was recorded in every week during the study. The fact that rainfall was unusually heavy limited the amounts required and effectiveness of irrigations. Seedlings on the area receiving Treatment 1 were not irrigated. Seedlings receiving Treatment 2 were irrigated only four times, with a total of 1.99 inches of water. Seedlings receiving Treatment 3 were irrigated nine times with a total of 3.47 inches of water.

TABLE 3 — *Rainfall and Soil Moisture, Herty Nursery, 1959.*

Period	Rainfall	Soil Moisture for Irrigation Treatments 1	2	3
	-inches-	Percent		
5/31 - 6/6	1.32	6.80+	6.80+	6.80+
6/7 - 6/13	.88	4.80	5.00	6.58
6/14 - 6/20	.00	3.84	5.20	8.29
6/21 - 6/27	.39	6.78	8.21	8.44
6/28 - 7/4	1.47	5.39	5.80	7.22
7/5 - 7/11	1.91	6.60	6.63	7.60
7/12 - 7/18	1.76	6.80+	6.80+	6.80+
7/19 - 7/25	.57	6.80+	6.80+	6.80+
7/26 - 8/1	1.20	4.75	5.40	7.55
8/2 - 8/8	.44	5.08	7.10	7.94
8/9 - 8/15	.62	4.80	6.15	8.50
8/16 - 8/22	.99	3.72	5.91	7.20
8/23 - 8/29	.18	3.59	6.07	7.72
8/30 - 9/5	1.56	6.80+	6.80+	6.80+
9/6 - 9/12	1.53	6.80+	6.80+	6.80+
9/13 - 9/19	1.02	6.80+	6.80+	6.80+
9/20 - 9/26	.00	.....	.....	.....
9/27 - 9/30	.00	.....	.....	.....
Number of Irrigations		2	7	10
Quantity of Water applied — inches		.46	1.63	2.75
Average Amount applied per Irrigation inches		.23	.23	.27

Rainfall at Albany, Georgia, during 1959 was 56.42 inches, or 8.86 inches above normal. Rainfall totaling 15.84 inches was recorded at the nursery during June, July, August, and September. This was 2.26 inches below normal for this period. The longest period without effective rainfall was 22 days from June 10 to July 1. The next longest drought period lasted 10 days from August 18 to August 28. Seedlings on the area receiving Treatment 1 were irrigated two times with a total of 0.46 inch of water. Seedlings receiving Treatment 2 were irrigated seven times with a total of 1.63 inches of water. Seedlings receiving Treatment 3 were irrigated ten times with a total of 2.75 inches of water.

The lowest average weekly moisture content of the soil at the Auburn Nursery was 4.61 percent. On some days during the longest drought period, the actual moisture content was close to the wilting point, but at no time did it drop below the wilting percentage (Table 2). There was no visible evidence of wilting during the drought period between mid-August and mid-September. However, this is usually the period during which nurserymen decrease rates of irrigation in order to hasten the hardening-off of plants.

At the Herty Nursery, visible indications of wilting from lack of moisture were pronounced during the drought period between June 10 and July 1. A small number of seedlings died before the seed beds were irrigated. The lowest recorded soil moisture during this period ranged between 3.57 to 4.02 percent. This represented a range of 5.6 to 3.5 atmospheres. Roots were less than five inches long until after the middle of July (Table 4).

The lowest average weekly moisture content of the soil at the Herty Nursery was 3.59 percent, which developed during the ten day drought period in late August (Table 3). The lowest recorded soil moisture percents were 2.17 on August 20, and 2.88 on August 28. A close inspection of the seedlings at this time showed no indications of wilting. Later observations revealed no detrimental effects to the seedlings.

Since the plants were unable to withstand soil moisture tensions of three to five atmospheres during the early growing period (June), it seems logical that their ability to survive soil moisture tensions close to 15 atmospheres later in the growing season is associated with root development, size, and adaptability.

The levels of soil moisture that prevailed during the two investigations did not significantly affect seedling growth. At the Auburn Nursery, the shortest seedlings were produced under the heaviest irrigation and tallest plants were produced under the medium irrigation. The longest roots developed in areas that received no irrigation.

TABLE 4 — *Mean Lengths (in inches) of Tops and Roots of Seedlings from the Auburn and Herty Nurseries.*

Dates (Mid-Month)	Tops Irrigation Treatments			Roots Irrigation Treatments		
	1	2	3	1	2	3
	Auburn Nursery-Loblolly					
July	4.7	4.6	4.2	5.6	5.6	6.1
August	6.2	6.0	6.0	6.8	6.2	7.0
September	8.1	7.9	6.8	7.2	7.7	7.3
October	9.6	9.8	7.7	7.9	8.0	8.2
November	9.1	9.7	8.7	9.0	8.6	9.3
December	8.5	10.3	7.6	10.9	9.7	10.0
	Herty Nursery-Slash					
July	5.1	5.2	5.7	4.6	4.6	5.1
August	7.5	8.0	8.5	5.5	6.1	6.5
September	8.8	9.6	10.4	7.0	7.3	7.8

Table 4 indicates that for the sandy soils of the Herty Nursery, stem and root lengths increased with increases in soil moisture. However, seedlings adjacent to the study received approx-

imately four inches more irrigation than the heaviest irrigation in the study. These seedlings were slightly smaller than those from the experimental area.

TABLE 5 — *Mean Oven-Dry Weights (in grams) of Tops and Roots of Seedlings from the Auburn and Herty Nurseries.*

Dates (Mid-Month)	Tops Irrigation Treatments 1	2	3	Roots Irrigation Treatments 1	2	3
			Auburn Nursery-Loblolly			
July	.290	.270	.250	.080	.060	.050
August	.703	.591	.703	.160	.124	.169
September	1.100	1.352	1.192	.223	.237	.291
October	2.039	1.782	1.760	.415	.414	.454
November	1.654	2.254	2.020	.920	.787	1.006
December	1.665	2.304	1.924	1.000	.820	.806
			Herty Nursery-Slash			
July	.412	.404	.471	.....	.....	.....
August	1.012	1.004	1.244	.....	.....	.....
September	1.870	2.540	2.346	.....	.....	.....

Dry weights of seedlings were not affected significantly by levels of soil moisture that prevailed in the two studies (Table 5).

The studies confirmed previous observations that root growth of southern pine seedlings increases after the time top growth decreases in the fall, and that the greatest accumulation of dry weight in the tops and roots is in the fall after stem elongation practically ceases. The values presented in Tables 4, 5, and 6 agree very closely with those reported by Huberman ([1]) and May ([3], [4]). Much of the increase in dry weight of tops and roots and in volume of roots during the fall seems clearly attributable to the storage of food not needed for stem growth or the active root growth then taking place.

Two seedling density levels and three rates of fertilization were included in the study at the Herty Nursery. At the time of lifting in December, 200 seedlings were removed from each of 54 treatments and graded according to Wakeley's ([5]) morphological grades. The levels of soil moisture that prevailed during the study did not affect significantly the total number of seedlings or the percentages of Grade 1 and Grade 2 seedlings. The smallest percentages of Grade 1 seedlings, however, were produced on plots that received the lightest application of water.

CONCLUSIONS

In the two studies reported, the same general results were obtained although the species, soil characteristics and techniques were quite different. Some fundamental relationships are apparent.

Soil moisture tensions greater than 3 to 5 atmospheres may cause permanent wilting to three-month-old slash pine nursery stock, especially when the roots are within the upper five inches of the soil layer.

Soil moisture tensions approaching 15 atmospheres or wilting percentage for a period of several days have no apparent detrimental effect on five or six month old loblolly and slash pine seedlings growing in nursery seedbeds.

The generally accepted concept that seedlings need about an inch of water a week from the time they are sown until late August or early September was not substantiated. A soil moisture content slightly below field capacity was necessary until the roots reached a depth of about five inches. This moisture level was maintained by the application of small amounts of water, i.e., about 0.25 inch per application. There was no need to establish or maintain a high moisture level below the zone of root penetration.

Supplemental irrigation of seedlings after an age of about three months or after the roots were longer than five inches did not affect the total number of seedlings produced, or modify the percentages of Grades 1 or 2 seedlings.

The course of seedling growth and development followed the same pattern, although the species, soil texture, and soil moisture were different. Further work is necessary to evaluate the effects of soil moisture or moisture stresses within the plant on the physiological characteristics of seedlings such as drought or frost hardiness or the ability to withstand transplanting or to initiate new growth.

TABLE 6 — *Means Cubic Volume (in cubic centimeters) of Tops and Roots of Loblolly Pine Seedlings from the Auburn Nursery.*

Dates	Irrigation Treatments		
	1	2	3
		Tops	
July	1.0	1.2	.9
August	2.0	2.1	2.3
September	3.8	4.5	3.8
October	5.4	6.1	5.4
November	5.0	7.5	5.8
December	4.9	7.2	5.8
		Roots	
July	.4	.5	.2
August	.3	.3	.4
September	.5	.7	.8
October	.9	.7	.9
November	2.3	2.0	2.1
December	2.6	2.0	2.0

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7. Agencies supporting the investigations were Auburn University, Alabama Division of Forestry, University of Georgia, Georgia Forest Research Council, Georgia Forestry Commission, and Southeastern Forest Experiment Station.

PIGMENT GENE EFFECTS ON BODILY PROPORTIONS IN MINK

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INTRODUCTION

In studying the constellation of effects associated with single genes in mutant coat-color strains of the long-domesticated Norway rat[1,2] differences in bodily proportion were found between individuals of particular gene constitutions. For example, the bodily proportions of waltzers were altered in that these animals became more stocky[3]. An effect associated with the Hooded gene tended to lengthen the tail[4], and this was evident in several coat color combinations involving the Hooded gene. We interpreted these associated effects to be due to pleiotropic manifestations of single coat color genes, because we could find no rat strains that were free from them.

A preliminary report was presented at the International Congress of Genetics in Stockholm in 1948[5], where two geneticists objected to our interpretation on the grounds that after the coat colors mutated originally other mutations took place in the same chromosome, these subsequent mutations modifying characteristics other than coat color. In this event, the phenomenon would be linkage rather than pleiotropy.

For this reason it would be of interest to examine the recently mutated coat colors of some mammal for similar modifications, since there would be very little opportunity for linked genes to have mutated after the mutation of the coat color genes.

MATERIAL AND METHODS

More than 1,125, skeletal dissections were made on ranch bred mink; the following parts were cleaned and dried for study: from the male the os penis, right tibia, right femur and skull; from the females the right tibia, right femur and skull. The bones were boiled in "Gold Dust" soap powder until the flesh was soft. They were then cleaned, dried and measured with calipers. The cranial capacity was determined by plugging the lesser foramena with wax and then filling the skull through the foramen with magnum fine shot which were then poured into a small graduate cylinder.

Most of the mink skeletons studied came from the annual crops and were of approximately the same age. However, a few had been saved as breeders for several years. These latter were examined in order to test the matter of heterogonic growth rates in various parts of the skeleton. For studying bodily proportions each bone measurement of length was recorded relative to the body length of the individual in question. We are studying, then, differences between ratios of statistical populations of bone length divided by body length by comparing their means. If the difference between two means is twice the standard error of that difference, then it is said to be significant (s).

RESULTS

We may compare the bodily proportions of Albinos of an annual crop with Old Albinos saved for several years as breeders. This comparison reveals that as the Albino mink matures more, the relative size of the os penis increases as would be expected. See figure 1. At the same time the tibia, femur and cranial capacity decrease. This simply means that the body length increases at a greater rate than the appendages and cranial capacity, a matter of heterogonic growth.

Albinos		Old Albinos	
		Males	
40 os penis .0732 ± .00032	<	9 os penis .0788 ± .000960	s = 3.5
38 tibia .0951 ± .000354	>	12 tibia .0896 ± .000592	s = 9.0
40 cran. cap. .179 ± .00154	>	12 cran. cap. .168 ± .00273	s = 3.5
		Females	
4 tibia .0967 ± .000785	>	3 tibia .0937 ± .000548	s = 3.1
4 femur .0876 ± .000130	>	3 femur .0855 ± .000499	s = 3.5
4 cran. cap. .166 ± .00238	>	3 cran. cap. .156 ± .00332	s = 2.4

Some data were collected on Screw Neck Pastel females to be compared with Old Screw Neck Pastel.

Screw Neck Pastel		Old Screw Neck Pastel	
		Females	
14 tibia .0941 ± .000527	<	5 tibia .0962 ± .000852	s = 2.1
14 femur .0851 ± .000524	<	5 femur .0861 ± .000232	s = 1.7
14 cran. cap. .166 ± .00220	>	5 cran. cap. .159 ± .00790	s = 0.8

There are also a few data from females of the Pastel-Blufrost combination:

Pastel Blufrost		Old Pastel-Blufrost	
		Females	
13 tibia .0941 ± .000609	<	19 tibia .0947 ± .000404	s = 0.8
14 femur .0847 ± .000495	<	19 femur .0854 ± .000280	s = 1.2
14 cran. cap. .155 ± .00199	>	18 cran. cap. .157 ± .00133	s = 1.6

The relationships here are exactly the same as those found between Screw Neck Pastel and Old Screw Neck Pastel, and in only one item, Screw Neck Pastel tibia, is the difference large enough to be statistically significant.

Normally with greater growth the rates of elongation of tibia and femur decrease relative to the rate of body elongation and the relative rate of cranial capacity increase is reduced. If this is true then in order to prove that we have come upon some alteration of bodily proportions due to presence of a coat color gene, we must demonstrate some violation of these normal heterogonic growth relationships. Otherwise, we have coat-color genes that merely stop development at different points along the normal heterogonic pathway of development.

Thus, if Pastel, for example, that grows larger than Dark mink, should show decrease in tibia length, femur length and cranial capacity, or if Blufrost, that grows less in body length than Dark, should show an increase over dark in tibia, femur, and cranial capacity, divided by body length, we would have to consider those findings merely to be a confirmation of the normal heterogonic growth rates.

Let us examine Dark in comparison with Pastel, a colorphase type that becomes somewhat larger than Dark in body size.

Dark		Pastel	
		Males	
40 os penis .0723 ± .000511	>	69 os penis .0720 ± .000524	s = 0.4
38 tibia .0970 ± .000451	>	74 tibia .0943 ± .000355	s = 4.7
37 femur .0880 ± .000378	>	75 femur .0854 ± .000540	s = 3.9
41 cran. cap. .163 ± .00118	<	75 cran. cap. .171 ± .00140	s = 4.4
		Females	
47 tibia .0960 ± .000335	>	54 tibia .0935 ± .000899	s = 2.6
47 femur .0863 ± .000461	>	53 femur .0852 ± .000665	s = 1.4
47 cran. cap. .151 ± .00133	<	54 cran. cap. .163 ± .00174	s = 5.5

Thus, we see that tibia and femur relative to body length decreases in Pastels as expected, but curiously enough, cranial capacity increases significantly in both males and females. The os penis does not change to any extent.

Silverblu grows still larger than Pastel, so let us compare Silverblu with Dark.

Dark		Silverblu	
		Males	
40 os penis .0723 ± .00511	<	49 os penis .0726 ± .000403	s = 0.9
38 tibia .0970 ± .000451	>	49 tibia .0956 ± .000403	s = 2.3
37 femur .0880 ± .000378	>	49 femur .0861 ± .000371	s = 3.6
41 cran. cap. .163 ± .00118	<	49 cran. cap. .176 ± .00135	s = 7.3

OS PENIS LENGTH ÷ BODY LENGTH
.0730
.0740
.0750
.0760
.0770
.0780
.0790
.0800
Old Albino
Os Penis Length
Black Cross
Silverblu Blufrost
Pastel Blufrost
Pastel Hybrid
Albino
Pastel Blufrost
Silverblu
Dark
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
TESTIS WEIGHT ÷ BODY WEIGHT

1.

Females

47 tibia .0960 ± .000335 > 36 tibia .0951 ± .000363 s = 1.8
47 femur .0863 ± .000461 > 50 femur .0845 ± .000328 s = 3.2
47 cran. cap. .151 ± .00133 < 50 cran. cap. .162 ± .00121 s = 6.7

Here again, the os penis is affected very little by the increase in body size. Again we find cranial capacity of the mutant increased over that of the Dark, whereas it is the tendency of heterogonic growth to decrease the relative cranial capacity as the body size grows larger. Our explanation is that gigantism brings acromegaly. If cranial capacity is compared between Pastel and Silverblu, Silverblu has a significantly greater cranial capacity in males, but not for females. For males the significance of that difference is 3.7.

Blufrost is smaller of body size than Dark. This comparison should shed light on heterogonic growth of tibia and femur. It should check on the suggestion that os penis size is independent of body size. It should provide data on the cranial capacity which should be larger than that of Dark, because the body is smaller.

Blufrost Dark

Males

8 os penis .0718 ± .00123 < 40 os penis .0723 ± .000511 s = 0.9
11 tibia .0943 ± .000578 < 38 tibia .0970 ± .000451 s = 3.7
11 femur .0855 ± .000401 < 37 femur .0880 ± .000378 s = 4.5
11 cran. cap. .158±.00216 < 41 cran. cap. .163±.00118 s = 2.0

Females

19 tibia .0957 ± .000566 < 47 tibia .0960 ± .000335 s = 0.4
18 femur .0854 ± .000286 < 47 femur .0863 ± .000461 s = 1.7
19 cran. cap. .156 ± .00121 > 47 cran. cap. .151 ± .00133 s = 2.8

Here once more the os penis size appears to be independent of body size because the difference is not statistically significant. Blufrost tibia and femur are smaller as expected. Blufrost cranial capacity is significantly reduced, but this appears to be an exception.

Let us examine Black Cross, a coat color variety somewhat reduced in body size.

Black Cross Dark

Males

28 os penis .0700±.000706 < 40 os penis .0723±.000511 s = 2.6
30 tibia .0955 ± .000454 < 38 tibia .0970 ± .000451 s = 2.4
30 femur .0871 ± .000358 < 37 femur .0880 ± .000378 s = 1.7
30 cran. cap. .168 ± .00167 > 41 cran. cap. .163 ± .00118 s = 2.4

Females

15 tibia .0962 ± .000749 > 47 tibia .0960 ± .000335 s = 0.2
32 femur .0869 ± .000655 > 47 femur .0863 ± .000461 s = 0.7
18 cran. cap. .157 ± .00234 > 47 cran. cap. .151 ± .00133 s = 2.2

It will be seen that in everything except Blufrost male-cranial capacity, the comparisons to Dark are as expected on the basis of heterogonic growth. The cranial capacity ratio in Blufrost females is still significantly greater than Dark.

In Black Cross males, os penis and femur are still less than Dark, but cranial capacity is greater than Dark. Black Cross females show tibia, femur and cranial capacity ratios larger than Dark.

It would appear that cranial capacity relative to body length starts out large, as is obvious in most mammals, and that the curve falls off normally in mink at the size of normal Dark. In those color varieties that grow larger than Dark the relative cranial capacity again increases as an acromegalic effect, as shown by Pastel and Silverblu.

The larger growth impetus of Pastel dominates somewhat over the growth retarding influence of Blufrost in crosses. We have recorded one case in which a population of 48 male Pastel-Blufrost with a mean weight of 3.80 ± .0617 pounds was almost as large as the mean weight of 3.82 ± .0345 pounds for a Pastel population of 238 male mink. Thus, we might expect Pastel-Blufrost proportions to approach those of Pastel. Let us compare Pastel-Blufrost with Dark.

Pastel-Blufrost		Dark	
		Male	
40 os penis .0739 ± .000734	>	40 os penis .0723 ± .000511	s = 1.8
40 tibia .0954 ± .00100	<	38 tibia .0970 ± .000451	s = 3.5
40 femur .0871 ± .000956	<	37 femur .0880 ± .000378	s = 0.8
40 cran. cap. .172 ± .000195	>	41 cran. cap. 163 ± .00118	s = 4.0
		Female	
44 tibia .0947 ± .000404	<	47 tibia .0960 ± .000355	s = 2.5
43 femur .0854 ± .000280	<	47 femur .0863 ± .000461	s = 1.7
40 cran. cap. .155 ± .00133	>	47 cran. cap. .151 ± .00133	s = 2.1

We see that Pastel proportions of os penis and cranial capacity dominate over Blufrost proportions in Pastel-Blufrost animals, although Pastel body size is larger than Dark. Whereas both Pastel and Blufrost have os penis lengths proportionately smaller than Dark, Pastel-Blufrost has an os penis proportionately larger than Dark. This may be explained as probably due to interaction between the two mutant coat color genes. The difference is actually 1.8 times the standard error of the difference between the means, whereas a relationship of 2.0 would be considered of proven significance.

We may compare the body proportions of Silverblu-Blufrost with those of Dark.

Males

Silverblu-Blufrost		Dark	
47 os penis .0742± .000408	>	40 os penis .0723 ± .000511	s = 2.9
51 tibia .0966 ± .000279	<	38 tibia .0970 ± .000451	s = 1.7
52 femur .0871 ± .000302	<	37 femur .0880 ± .000378	s = 1.9
52 cran. cap. 171 ± .00132	>	41 cran. cap. .163± .00118	s = 4.5

Females

8 tibia .0960 ± .000523	—	47 tibia .0960 ± .000335	s = 0.0
8 cran. cap. .162 ± .000264	>	47 cran. cap. .151 ± .00133	s = 3.7

Here we find the same relationship between Silverblu-Blufrost and Dark that we found between Silverblu and Dark. The Silverblu-Blufrost os penis is significantly longer than Dark. Thus, the proportions of Silverblu tend to dominate over Blufrost in os penis length and cranial capacity.

Now that we have compared these homozygotes for two coat color genes with Dark, we should compare the effects of the genes in simplex with each other.

Males

Pastel-Blufrost		Pastel	
40 os penis .0739 ± .000734	>	69 os penis .0720 ± .000524	s = 2.1
40 tibia .0954 ± .000100	>	74 tibia .0943 ± .000355	s = 3.0
40 femur .0871 ± .000956	>	75 femur .0854 ± .000540	s = 1.5
40 cran. cap. .172 ± .00195	>	75 cran. cap. .171 ± .00140	s = 0.0

Females

44 tibia .0947 ± .000404	>	54 tibia .0935 ± .000899	s = 0.0
43 femur .0854 ± .000208	>	53 femur .0852 ± .000665	s = 0.0
40 cran. cap. .155 ± .00133	<	54 cran. cap. .163 ± .000174	s = 3.6

Although three of the comparisons have no significance, it is notable that the Pastel-Blufrost os penis is statistically longer than Pastel and again demonstrates gene interaction. The cranial capacity of Pastel-Blufrost females is less than that of Pastel.

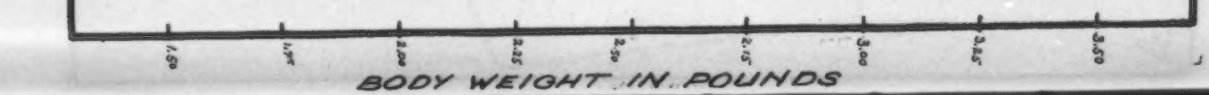
We have some data for comparing Silverblu:

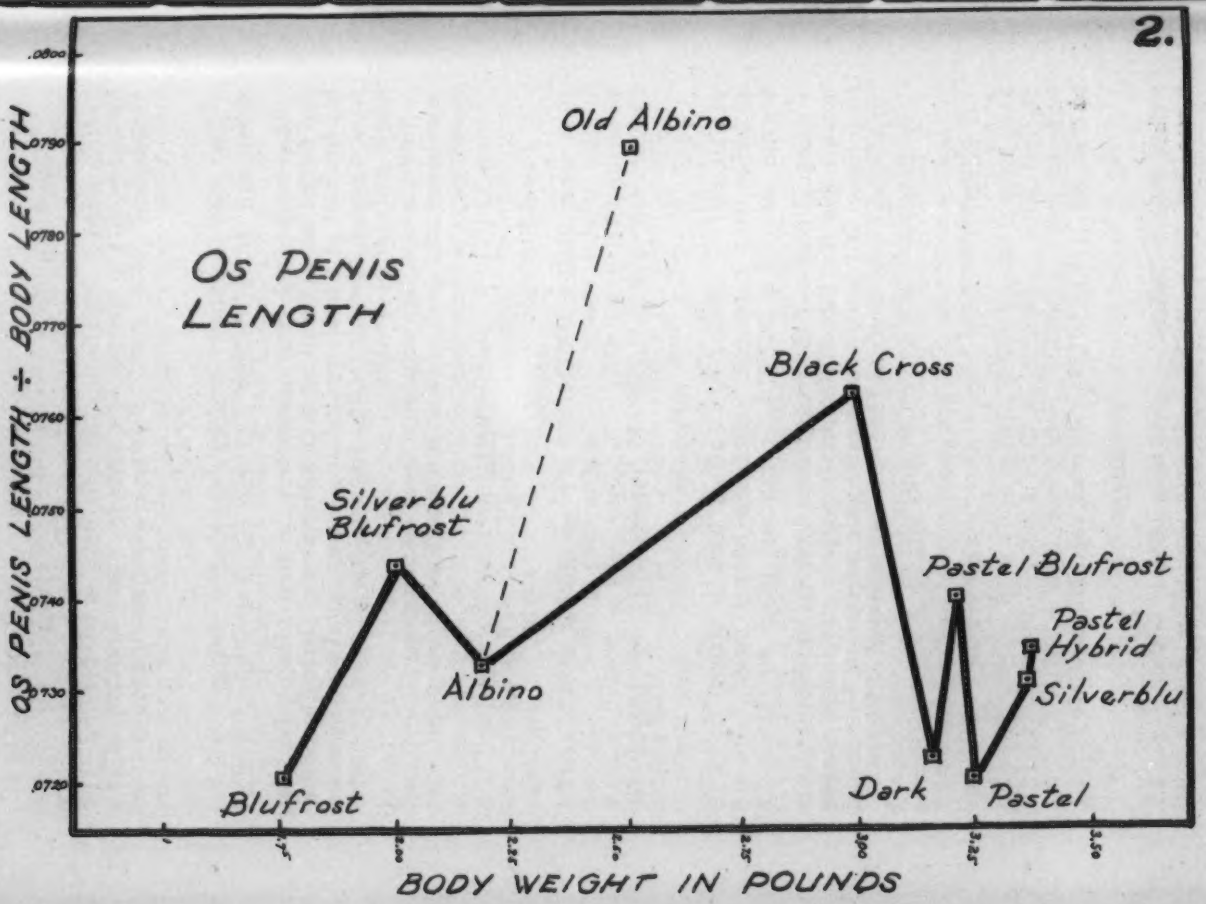
Males

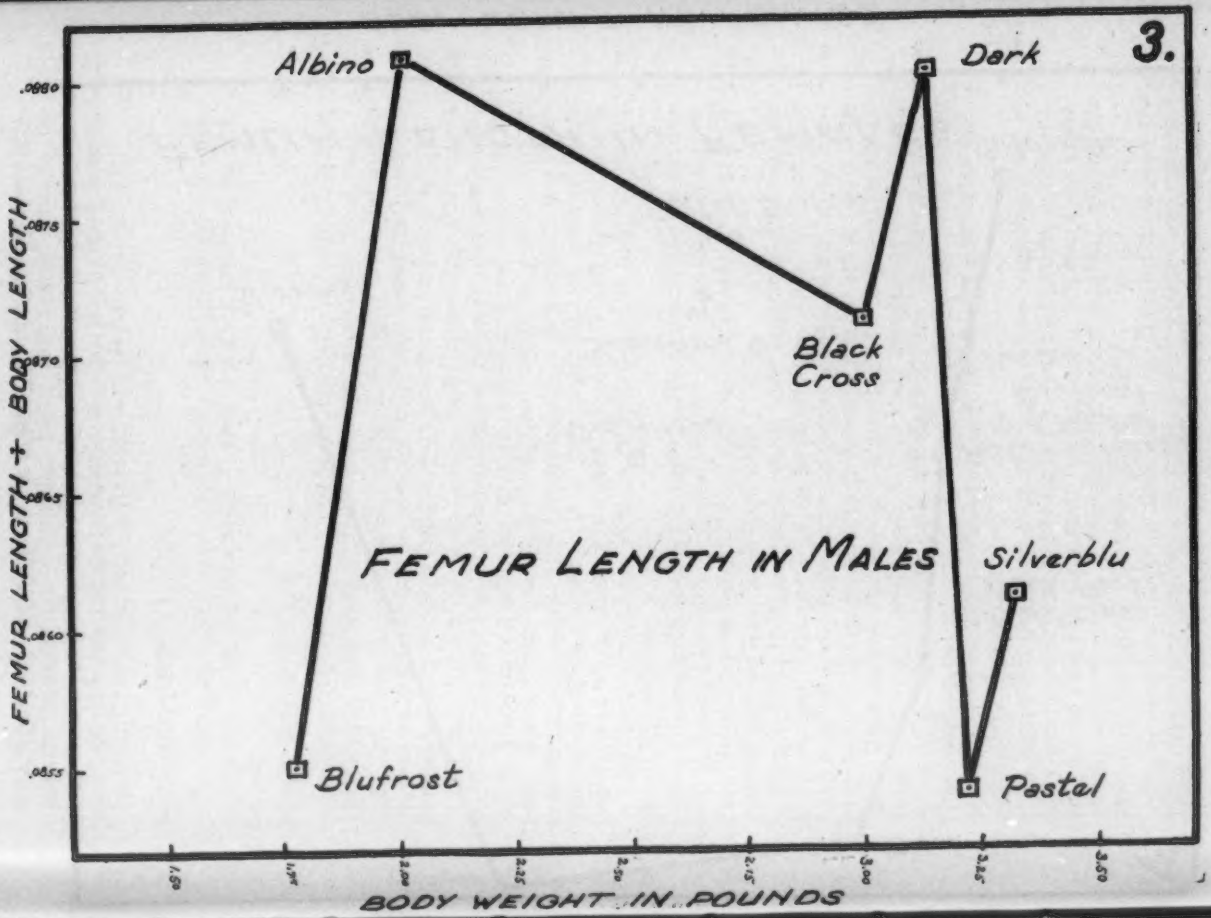
Silverblu-Blufrost		Silverblu	
47 os penis .0742 ± .000408	>	49 os penis .0726 ± .000403	s = 6.3
51 tibia .0966 ± .000279	>	49 tibia .0956 ± .000403	s = 2.0
52 femur .0871 ± .000302	>	49 femur .0861 ± 00371	s = 2.1
52 cran. cap. .171 ± .00132	<	49 cran. cap. .176 ± .00135	s = 2.1

Females

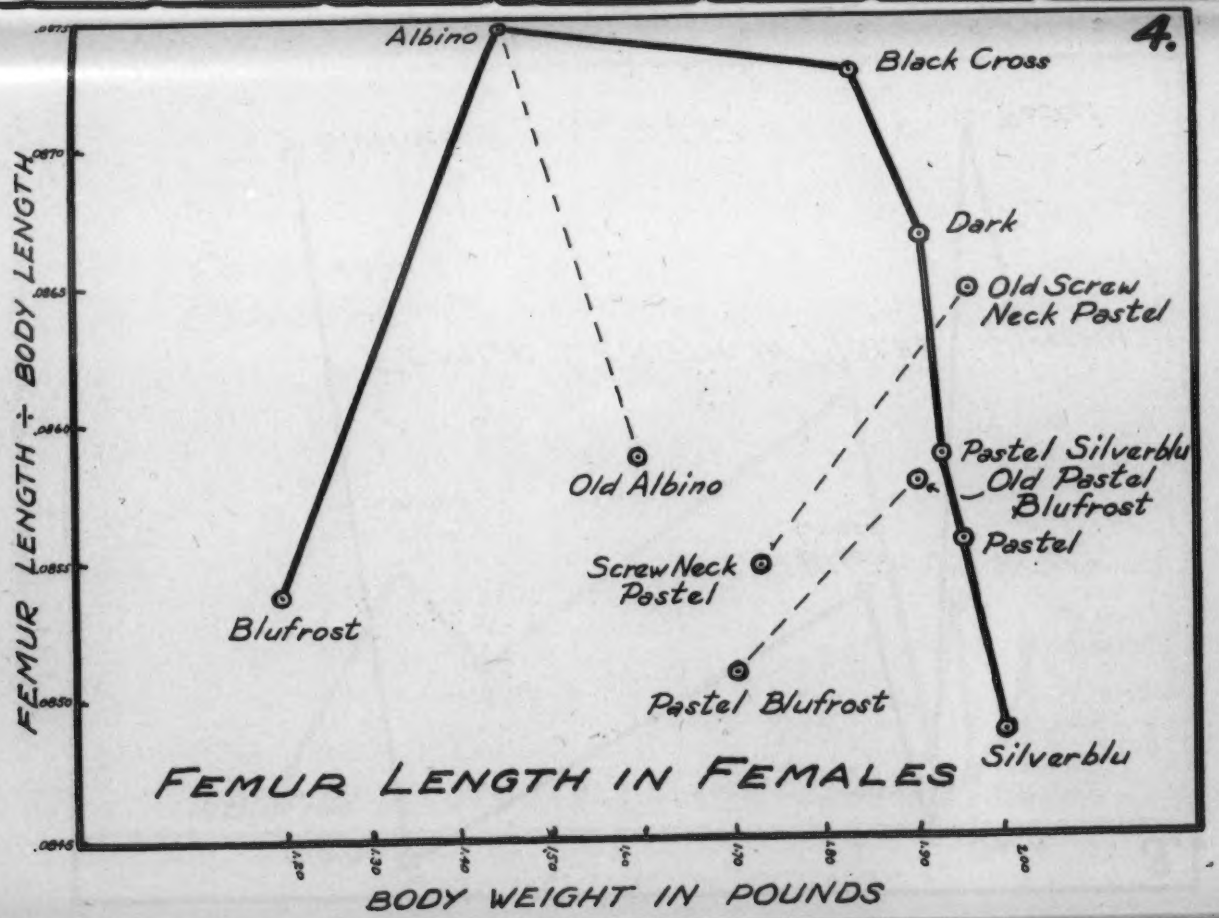
8 tibia .0960 ± .000523	>	36 tibia .0951 ± .000363	s = 1.7
8 cran. cap. .162 ± .00264	—	50 cran. cap. .162 ± .00121	s = 0.0


BODY WEIGHT IN POUNDS


2.
OS PENIS LENGTH ÷ BODY LENGTH
.0800
.0790
.0780
.0770
.0760
.0750
.0740
.0730
.0720
OS PENIS LENGTH
Old Albino
Black Cross
Silverblu Blufrost
Pastel Blufrost
Pastel Hybrid
Silverblu
Albino
Blufrost
Dark
Pastel
BODY WEIGHT IN POUNDS


3.
Albino
Dark
Black Cross
Blufrost
Pastel
Silverblu
FEMUR LENGTH IN MALES
FEMUR LENGTH + BODY LENGTH
.0880
.0875
.0870
.0865
.0860
.0855
1.95
2.00
2.25
2.50
2.75
3.00
3.25
3.50
BODY WEIGHT IN POUNDS

2.


4.
Albino
Black Cross
Dark
Old Screw Neck Pastel
Pastel Silverblu
Old Albino
Old Pastel Blufrost
Pastel
Screw Neck Pastel
Blufrost
Pastel Blufrost
Silverblu
FEMUR LENGTH IN FEMALES
FEMUR LENGTH ÷ BODY LENGTH
.0875
.0870
.0865
.0860
.0855
.0850
.0845
BODY WEIGHT IN POUNDS
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.00

The os penis of the Silverblu-Blufrost combination is very significantly larger than Silverblu. Tibia and femur tend to be larger in the combination of Silverblu-Blufrost, which one might expect on the heterogonic grounds due to the greater size of Silverblu. Cranial capacity is greater in Silverblu males.

TAIL-BODY RELATIONS

The tail-body ratios were studied for all populations, but since no significant alterations were found, the data will not be presented.

DISCUSSION

In order to examine the data of all populations for each type of comparison, they were plotted on a series of charts.

At first thought one might suspect a straight line relationship between os penis length divided by body length and testis weight divided by body weight. Critical data are shown in figure 1.

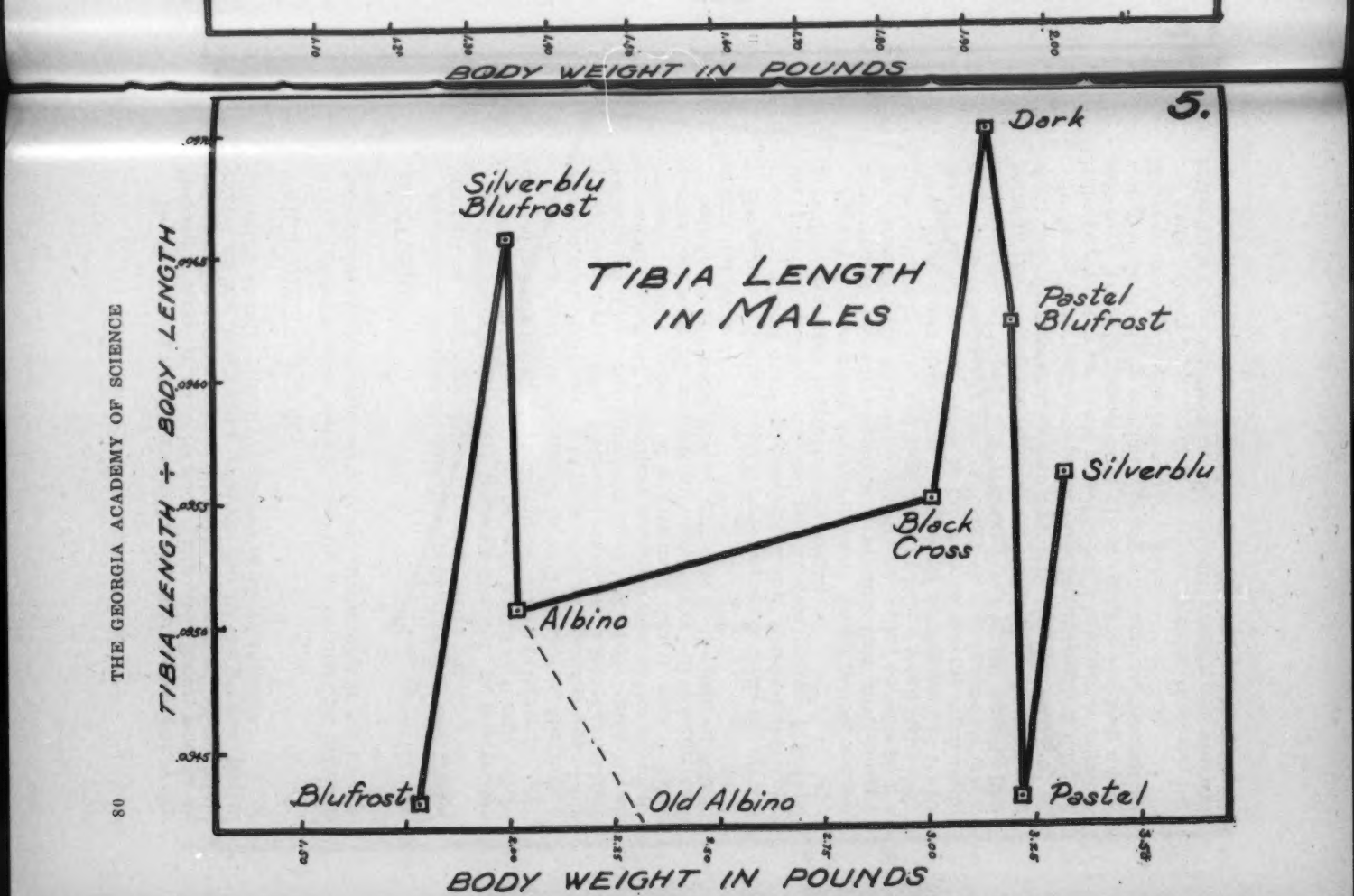
The data have a wide spread in both directions. Blufrost, a small animal, and Pastel, a large animal, have similar penis-body ratios. Dark have a large testis-body ratio, but a low os penis-body ratio. Black Cross has a medium sized testis-body ratio, but an enormous penis-body ratio. Other coat-color populations are intermediate in both respects. It is presumed that in each of these populations when the animals grow older there will be an increase in both testis and penis size, as indicated by the data on Albino versus Old Albino.

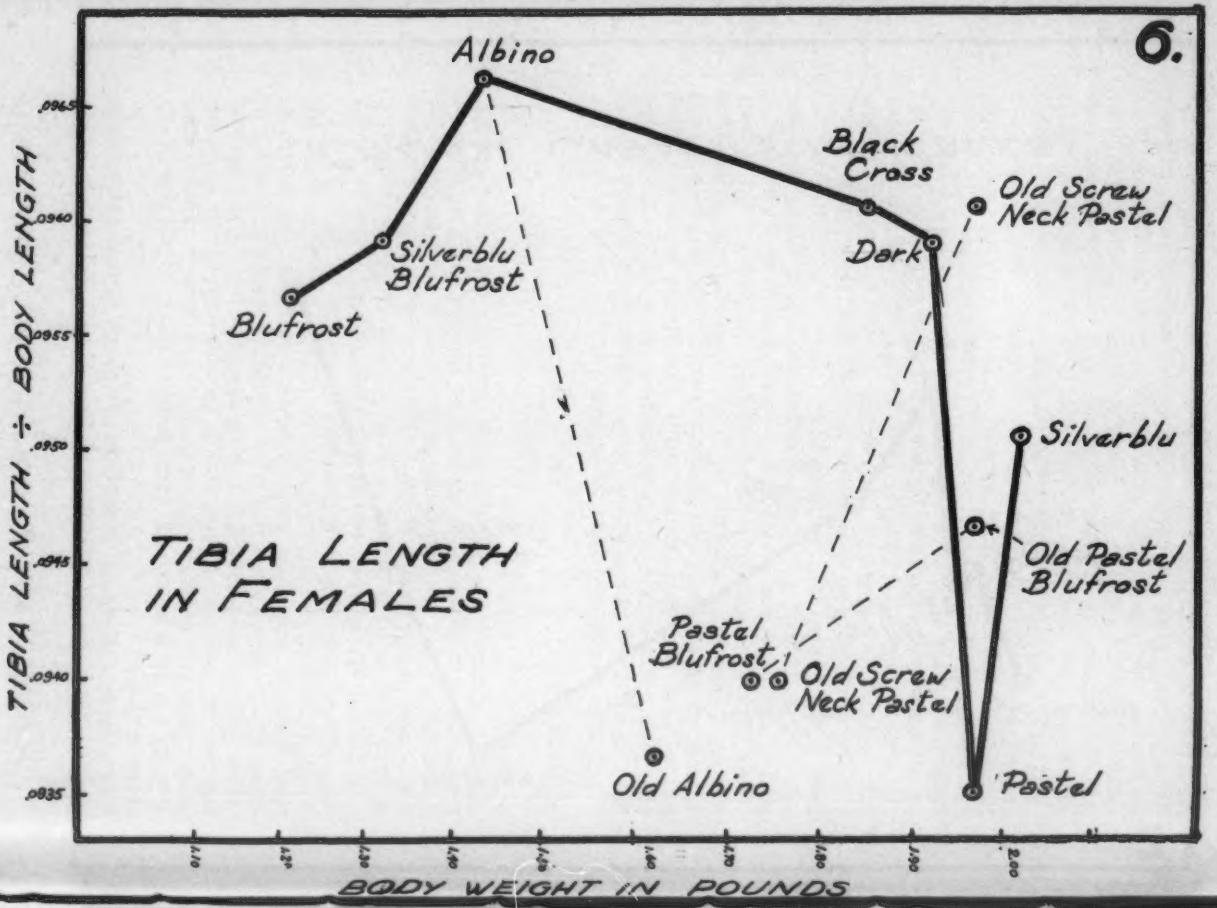
But although distinct penis-body ratios characterize the several coat-color strains quite independent of the testis-body ratio, we may plot the penis-body material against some measure of general growth such as body length or body weight.

Figure 2 shows testis divided by body length plotted against body weight. The curve is an arch showing that small animals have a small testis-body ratio, intermediate sized animals have a high testis-body ratio, and large animals have a small testis-body ratio. This shows that there is a spurt of development of the os penis that waxes and wanes as the body in general continues to grow at a more steady rate, although it, too, is slowing down. The relative penis-body size is determined in the main by the point in the heterogonic pathways at which the coat-color gene stops body development.

In figure 3 are plotted data for male femur length divided by body weight, since we would expect to find a heterogonic relationship here. There is a spurt of the femur growth and then a subsiding while the body continues to grow on and on, causing the larger animals to be relatively short legged.

Figure 4 shows much the same thing for females. However, the ratio drops more and more in Albinos with greater age, whereas in Screw Neck Pastel and Pastel Blufrost the ratio rises again.


5.
TIBIA LENGTH IN MALES
TIBIA LENGTH ÷ BODY LENGTH
BODY WEIGHT IN POUNDS
Dork
Silverblu Blufrost
Pastel Blufrost
Silverblu
Black Cross
Albino
Old Albino
Blufrost
Pastel


6.
TIBIA LENGTH ÷ BODY LENGTH
.0965
.0960
.0955
.0950
.0945
.0940
.0935
Albino
Black Cross
Old Screw Neck Pastel
Dark
Silverblu Blufrost
Blufrost
Silverblu
Old Pastel Blufrost
TIBIA LENGTH IN FEMALES
Pastel Blufrost
Old Screw Neck Pastel
Old Albino
Pastel
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.00
BODY WEIGHT IN POUNDS

5.
Dark

CRANIAL CAPACITY ÷ BODY LENGTH
.180
.175
.170
.165
.160
.155
Albino
Old Albino
Silverblu
Silverblu Blufrost
Blufrost
Black Cross
Pastel Blufrost
Pastel
Dark
7.
CRANIAL CAPACITY IN MALES
BODY WEIGHT IN POUNDS
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50

Figure 5 shows the curve for male tibia length divided by body length plotted against weight. Here Albino and Black Cross fall below Silverblu-Blufrost and Dark, and with age the tibia-body length ratio of Albino continues to become shorter. This deviation of Albino and Black Cross may be due to the chance variation of small samples.

Figure 6 gives much the same picture for females. Old Screw Neck Pastel and Pastel-Blufrost increase the tibia-body ratio with age just as was true of the femur, having started out with low ratios. These latter two types have not been put on the general curve due to small numbers. Here, again, is indicated a spurt of tibia growth, while the body continues to grow. At whatever point the general growth is stopped by the coat-color gene the heterogonic relationship of tibia size is found.

Figure 7 shows the cranial capacity divided by body length plotted against body size in weight for males. There is an arch curve, the head being originally large and then becoming relatively small. The normal Dark mink strike a low for the ratio. However, animals growing larger than normal spurt up again in this as if due to acromegaly. Albino continues downward in ratio with age.

SUMMARY

We have compared bone measurements for more than 1,125 mink of strains containing coat-color mutations of recent origin, plus their Dark controls. These populations of data were all collected from the same animal crop, except for several strains allowed to live a year or so longer in order to determine changes due to greater age. Because of sexual dimorphism males were compared only with males and females with females. Each bone length measured was divided by the body length of the animal to which it belonged. Thus, our comparisons were made between bone lengths relative to body length.

The bones studied were penis, femur, and tibia. In addition, cranial capacity divided by body length was examined. The means for each population of ratios were determined. Standard error of the mean was calculated. When the values of two means were compared, their difference was obtained, and this was divided by the standard error of the difference. If the difference was two or more times the size of the standard error of the difference, then the difference was considered to be statistically significant.

By this method of analysis and by plotting the means of these ratios, we have been able to show (1) that the os penis length is not correlated with relative testis size and, hence, male sex hormone concentration. (2) We found that the os penis has a spurt of growth that fades out more rapidly than the general body growth rate. There is a heterogonic relationship between os penis growth and general growth rates, and the main differences in

bodily proportions found to exist between different coat-color strains of mink are due to stopping development at a particular point on the heterogonic paths. Old Albinos, and presumably, the others increase the os penis divided by body length ratio.

Similar spurts of growth were noted for femur and tibia in both males and females, Old Albino males reducing the ratio with age whereas both Screw Neck Pastel and Pastel Blufrost females increase the ratio.

Cranial capacity divided by body length likewise shows a spurt and decline in both sexes, but animals larger than Dark, such as Pastel Bluefrost, Pastel, and Silverblu, show an increase in ratio. This latter rise in the curve we interpret as being due to acromegaly. All old animals of strains smaller than Dark reduced the ratio with greater age.

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FOREST SERVICE RESEARCH ACTIVITIES IN GEORGIA

W. A. CAMPBELL
Southeastern Forest Experiment Station
Macon

The Forest Service is probably the best known agency of the United States Department of Agriculture. Its name is linked indelibly in the public mind with the national forests, public camp and recreation areas, hunting and fishing, and Smokey Bear. It is the agency entrusted with the management of 180 million acres of forest land for, in the words of one of its early leaders, "the greatest good for the greatest number in the long run." The national forests are among the few self-sustaining governmental units; each year they return to the Federal Treasury more than Congress appropriates for their operation. The Forest Service also assists landowners with the management of millions of additional acres of forest land through its State and private forestry programs.

For administrative purposes the Continental United States is divided into nine regions. Region Eight, with headquarters in Atlanta, operates 9,000,000 acres of national forest land in ten southern states. The Chattahoochee National Forest and the newly created Oconee National Forest embrace roughly 700,000 acres of forest land in Georgia. As vast as this area may seem it comprises less than 5 percent of the total forest land of the State.

The Forest Service spends 10 percent of its budget on research. Most of this research is planned and directed at nine regional experiment stations and the Forest Products Laboratory at Madison, Wisconsin. The Southeastern Forest Experiment Station at Asheville, North Carolina, is responsible for research in Virginia, North Carolina, South Carolina, Georgia, and Florida. The research programs are largely developed and carried out at field research centers, experimental forests, and cooperating institutions throughout this territory.

In Georgia active and productive research programs are carried on at the Macon Research Center with installations at Cordele, Macon and Athens. Field experiments are conducted mainly at the George Walton Experimental Forest, Cordele, the Hitchiti Experimental Forest, near Gray, and the Toccoa Experimental Forest in North Georgia. Much of this work is in cooperation with the University of Georgia, the Georgia Forestry Commission, and the Georgia Forest Research Council. The Forest Service also operates the Regional Forest Fire Research Laboratory built at Macon by the Georgia Forest Research Council.

Forest research had its beginnings in Georgia in 1930 when the Appalachian Forest Experiment Station at Asheville received $5000 for studies on the growth rate and general condition of the hardwood forests in the mountain area. This project was in

cooperation with the Mountain Experiment Station at Blairsville and was confined to lands above 2000 feet in elevation. To further expedite this work the Toccoa Experimental Forest was established in North Georgia in 1934. Studies on white pine management were added to the Toccoa program soon afterwards and experimental plantings of hybrid poplars and other exotic species were established.

The first state-wide forest survey of the timber resource in Georgia was completed in 1934; the second survey was made during 1951-54; and the third survey is now underway and scheduled to be completed in 1961. These surveys are extremely valuable to forest managers and industries since they show trends in timber supply and drain on forest resources. The Division of Forest Economics has also conducted marketing studies in several Georgia counties in cooperation with the Georgia Experiment Station.

A reorganization of the research branch of the Forest Service changed the name of the Appalachian Forest Experiment Station to the Southeastern Forest Experiment Station in 1946 and enlarged its territory to include all of the South Atlantic States from Virginia through Florida.

Range management research on methods of integrating cattle raising with timber management was started in 1947 on the Alapaha Experimental Range in Berrien County in cooperation with the Georgia Coastal Plains Experiment Station at Tifton. This work is still continuing under direction of the Lake City, Florida, Research Center.

Forest disease research has been carried on at Athens since 1940 in cooperation with the School of Forestry of the University of Georgia. The early investigations were concerned with the nature and cause of littleleaf disease of shortleaf pine. Recently emphasis has been placed on basic studies on tree mycorrhizae, hardwood defects, and on the development of shortleaf pines resistant to littleleaf disease.

Major research on problems of hardwood management and utilization were started at the University in 1954 by the formation of the Athens Research Center. Featuring better forest management, reduction of defect, and more effective utilization, this work has continued unabated and has been greatly enhanced by the strong forest research program developed by the School of Forestry. At present the University of Georgia and the Forest Service, working together, are conducting one of the most intensive and productive forest research programs in the South.

Research at the Hitchiti Experimental Forest near Gray started in 1945. Here a comprehensive test of management systems for loblolly pine is reaching a fruitful climax. With the development of the Georgia Forestry Center a strong research program was initiated with the cooperation of the Georgia Forestry Commission and the Georgia Forest Research Council to solve many of

the technical problems connected with the State's reforestation, timber management, seed procurement and other programs. At the present time research is being conducted on tree breeding, control of nursery diseases and insects, wood utilization, seed storage and treating techniques, nursery soil and agronomic problems, weed control, and many other problems.

The location of the Regional Seed Testing Laboratory at Macon and the construction of a modern laboratory building to house it and provide it with adequate facilities and equipment has greatly aided research on all phases of the procuring, processing, storing, and handling of tree seeds. This laboratory serves the entire eastern United States.

The Forest Fire Research Laboratory at Macon is an outstanding example of the development of a modern facility to study the basic and applied phases of fire behavior, mechanics, and control. This laboratory is being staffed by foresters, physicists, physiologists, and engineers whose efforts will be directed toward solving many of the basic problems connected with forest fires and their control. This regional laboratory is of importance in national defense because of the incendiary threats that modern warfare presents.

At Cordele the George Walton Experimental Forest serves as a pilot plant to test systems of managing slash and longleaf pines for their greater contribution to the regional economy. Here, also, is centered research on plantation management for pine species planted in the coastal plain.

Research Centers outside of Georgia, notably the Coweeta Hydrologic Laboratory near Franklin, North Carolina, and those at Lake City, Florida and Union and Charleston, South Carolina, carry on research applicable to many forest types in Georgia. The work on naval stores at Lake City is of particular importance since Georgia is the number one producer of naval stores in the country.

Originally, nearly all forest research was of the applied type. More recently the Forest Service has increased its efforts in basic research. This type of research is given impetus through cooperation with the University of Georgia and at the modern laboratories located at the Georgia Forestry Center.

Most of the Forest Service research in the South is helped in one way or another by a number of cooperating agencies. Several of these have been mentioned. Forest industries, particularly the pulp and paper companies, have been particularly generous with contributions of land, equipment, and services. Georgia can be proud of the research carried on within its borders not only by the Forest Service but by its State organizations and private companies. The generous spirit of cooperation shown by all has produced a strong forest research program aimed at keeping Georgia forest resources geared to the demands of an expanding population and improved standard of living.

Withdrawn

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